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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

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Lieut.-General J. F. TENNANT, C.I.E., R.E., F.R.S., President, in the Chair.

Sir George Errington, Bart., Lackham Manor, and Brooks's Club, St. James's Street, S.W.;
Edward Robinson, 4 Castelnau Gardens, Barnes, S.W.;
Andrew Simons, Her Majesty's Dockyard Schools, Devonport,

were balloted for and duly elected Fellows of the Society.

The following candidate was proposed for election, the name of the proposer from personal knowledge being appended :—

Thomas Steele Sheldon, M.B. Lond., Cheshire County Asylum, Macclesfield (proposed by Rev. T. Harley).

On the Nautical Almanac.

By Lieut.-General J. F. Tennant, C.I.E., R.E., F.R.S.

About a couple of years ago I communicated to the *Observatory* a paper on this subject in the hopes that astronomers with varied experiences would offer suggestions for removing imperfections in our National Ephemeris. The result was very small, but this was not due, I think, to a belief that the Almanac is incapable of improvement so much as to the fact that its weakest points do not force themselves on the notice of those who are resident near its first meridian, and who use it mainly in preparing for or reducing observations for publication.

If we examine the contents of the *Nautical Almanac* we find that we can arrange them under four heads with convenience.

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1st. *The General Ephemeris*, whose arguments are separated by equal intervals of time, and whose data are mainly materials from which the circumstances and nature of observable phenomena may be readily deduced. It is evident that these data should be given in a form which would make them most readily available for use wherever the observer may be situated. Inasmuch as the data of this section are the sources from which those of the next are derived, it follows that changes will generally be of convenience in arrangement; but there are some cases where data can be more conveniently given and also additions made of matter wanted or omissions of what has become useless.

2nd. *The Greenwich Ephemeris*, containing information more directly prepared for comparison with observation at Greenwich and readily adapted to the neighbourhood. Naturally this section requires little or no change save rearrangement.

3rd. *The Nautical Ephemeris* would much overlap the sphere of the first section: but distinctively only includes such matter as finds its use at sea, or under the circumstances of restriction in instrumental means to which travellers and explorers are subjected.

4th. *The Computing Section*, of which the contents are mainly used in computing orbits and ephemerides and in investigations connected with them.

I propose first to consider the question of arrangement which is important to convenient use, and then to pass to consider section by section the form in which the matter under each head should be given. And in the first place I would remark that in our present *Nautical Almanac* the matter under all the sections has been mixed up, so that the finding of what is wanted is less easy than it might be; and, what is worse, the user of the *Nautical Almanac* for any one purpose is encumbered with matter he does not want, or has in a more convenient form. I should therefore propose that each section should be separately paged, and, even if not sold separately, should be capable of being severed from the rest, so that everyone might combine the parts as he chose. Naturally the Greenwich Ephemeris would be of little use to the observer or worker in Australia or India: the observer in Britain would find the Greenwich Ephemeris most handy for his observatory or many other purposes; while neither would care to be constantly encumbered with the computing matter, or with that which I have above called the Nautical Section.

In each section I would place all matter relating to the Sun alone together, then the Moon, then the principal Planets in order according to their distances from the Sun; then would come the asteroids, whose ephemerides, if given, would probably only extend over part of the year; lastly the stars, and then eclipses, occultations, and miscellaneous matter. It may possibly be occasionally necessary to depart from the strictness of this

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order for economy of space, but I hope not. I believe that consideration has been carried too far, and that the result of such departures from system is often too high a price to pay for the gain. In order to facilitate the determination of errors of the tables the ephemerides should contain the results deduced from those alone. Where experience shows that empirical corrections will improve the agreement with observation, those would be applied in any elements for prediction, &c., but not to the ephemeris. Thus in the case of the Moon, Hansen's Tables would be used corrected for the error in Table xxxix. (where one included term is wrong in sign and value), but the other corrections proposed by Professor Newcomb would be applied before forming the elements for eclipses and occultations.

I now proceed to consider the contents of the First Section, and I shall refer to the pages of the *Nautical Almanac* of the current year containing each item.

	Page of *N.A.*
Articles of the Calendar	ix.
Abbreviations and Symbols	x.
Parallax of Sun (could be put below this on page)	1.
Phenomena	466–7
Sun's Places, Semi-diameter, Equation of Time and STMN.*	ii. of each mo.
Moon's Places, Semi-diameters and Parallaxes and Phases	v. to xii. & iv. of mo.
Empirical Corrections to Moon's R.A. and Dec.	
Mercury, R.A., Dec. at Noon, Semi-diameter & Parallax	pp. 226–233 & 270–273
Venus, ,, ,, ,,	234–241 & 274–77
Mars, ,, ,, ,,	242–49 & 278–81
Jupiter ,, ,, ,,	250–57
Saturn ,, ,, ,,	258–265
Uranus ,, ,, ,,	266–267
Neptune ,, ,, ,,	268–269
Asteroids ,, ,, ,,	Appendix
Stars, Apparent places	pp. 313–368
Eclipses	399–404
Elements of Occultations	405–440
Satellites of Mars.	
,, ,, Jupiter, Eclipses, Transits, and Configuration	pp. 444–465
,, ,, Saturn, and Elements of Ring as in	p. 468
,, ,, Uranus.	
,, ,, Neptune.	

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* I doubt if the Mean time of Transit of First point of *Aries* is of much practical use.

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Remarks on above.—The mode of putting the Moon's semidiameters and parallaxes below the Polar coordinates of the day, adopted in the *Connaissance des Temps*, seems to me convenient. I would add in the same way the mean times of the transits; the phases might, as now, close the month, or be placed at the beginning of the Almanac. I have entirely omitted the Moon-culminating Ephemeris, which in its present form I look on as valueless save for Greenwich. If the times of transit and the coordinates of the Moon could be given for each hour of longitude, somewhat as in the *Connaissance des Temps*, they would be useful; but it is a question if the gain would be worth the cost. If anyone will try to use the present Table of Moon-culminating places for the purpose of determining the right ascension of the Moon's centre, or that of the limb, and the hourly motion, say at Madras, he will be satisfied that there is a more ready way of gaining his object.

As regards the Stars. The list should be greatly increased. There should be no difficulty about this. The *Berliner Jahrbuch* gives a list of the mean places of 622 stars of which the ephemerides are given for some 450, and the *Connaissance des Temps* gives ephemerides for 360. Uniformity would require that the places should be given for mean noon or midnight at Greenwich, and I do not think that this would be practically inconvenient; but as stars are generally observed on the meridian, the present arrangement offers advantages and might stand. Eclipses and occultations should have their elements given so as to facilitate as much as possible the computation of local phenomena. The arrangement of elements of occultations in the *Connaissance des Temps* is the most complete, but that of the American *Nautical Almanac* is more compact, and practically suffices. A similarly convenient form is to be found in Dr. Anton's *Ephemeris*, published at Trieste, in which the data are taken from the *Nautical Almanac*. The mode of giving the elements for eclipses recently in the *Connaissance des Temps*, and, from somewhat similar formulæ, in the American *Nautical Almanac*, seems to me to offer most convenience for use.

I see no reason why the information as to Satellites should be confined to *Jupiter's*, and have included those of all planets known to have any. I should like to see a uniform system for enabling the observer to recognise the configurations. The mode of exhibiting those of *Jupiter's* satellites is unsatisfactory when the times of observation differ from those employed; but there are of course other means of distinguishing these satellites than their positions.

I would suggest further that the Star ephemeris might be made a sub-section so that it could be attached to any of the sections which may be preferred.

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2nd. *The Greenwich Ephemeris* would contain

Solar Ephemeris at Transit	p. i. of month
Lunar Ephemeris, being Moon-culminating Stars, omitting Lower Transit	pp. 369–398
Mercury at Transit	270–273
Venus ,,	274–277
Mars ,,	278–281
Jupiter ,,	282–284
Saturn ,,	285–287
Uranus ,,	288–289
Neptune ,,	p. 290
Eclipses for British Observatories	401
Occultations at Greenwich	pp. 441–443
Satellites of Jupiter, Eclipses, &c., for Greenwich	444–465

I should propose to extract the eclipses of *Jupiter's* satellites, &c., from the general list so far as they are visible in the United Kingdom. I presume in all other matters English astronomers have secured almost all that they especially want, and that any changes will be very trifling.

3rd. *The Nautical Section.*—Considered merely as a portion of the volume this would contain only

Lunar Distances, pp. xiv. to xviii. of mo.	
Table for 2nd Difference Correction	p. 482
Tables for correcting Lunar Distances for the Earth's figure.	
Table for Latitude by Polaris	pp. 483–485
,, ,, Azimuths by ,,	
,, ,, Tides	476–479

I have added a table for azimuths by *Polaris* because I think this would be useful to surveyors, and not less so in navigation, especially in low latitudes. I should very much like to see tables, such as those in the *Berliner Jahrbuch*, for correcting lunar distances for the effects of the figure of the Earth; they would be probably rarely used at sea, but would be valued by all careful observers everywhere. As regards tides, I should like to see tide tables given for the principal ports whenever there are data for computing them accurately, as there now are, I believe, for many points on the coast. The cost of mechanical computation would be but trifling, and there seems no reason why London should be the sole tidal station. As a rule I fancy that heights, unless readily convertible to heights over a bar or shallow, would not be of much use to seamen.

Lastly we come to the *Computing Section.* The ephemerides

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in this would be latitudes and longitudes, but all data would be referred to the equinox of the beginning of the year when the Sun's longitude is 280°. The contents would be:—

The matter contained in page 1 of the *Nautical Almanac*, save that the mean obliquity and precession should be referred to the above date instead of January 1·0.

The Sun's Longitude, Latitude, and Log Rad Vector ...	p. iii. of month.
The Sun's Co-ordinates for Mean Equinox of above date	pp. 218–225
The Moon's Latitude, Longitude	p. iv. of month.
Empirical Corrections to Moon's Latitude, Longitude ...	pp. xv. & xvi. of App.
Mean Longitudes, &c., of Moon and its Node.	
Heliocentric Longs., Lats., and Distances, Mercury	226–233
,, ,, ,, Venus	234–241
,, ,, ,, Mars	242–249
,, ,, ,, Jupiter	250–257
,, ,, ,, Saturn	258–265
,, ,, ,, Uranus	266–267
,, ,, ,, Neptune	268–269
Mean Places of Stars	292–295
Bessel's Formulæ of Reduction	p. 296
,, Day Numbers	pp. 297–304
,, Independent Constants	305–312
Day of Year, and Corresponding Day of Julian Period.	
Latitudes and Longitudes of Observatories.	

In the *Berliner Jahrbuch* the latitudes and longitudes of the Moon are only given to one-tenth of a minute. This accuracy would suffice for the Moon, and equally for the smaller planets, but (unless space be wanting) I would propose to give them all to the nearest second. *Jupiter* and the planets beyond should have them given to $0''\cdot 1$. In the cases of the planets daily places would be unnecessary, but I would propose that they be given for every fifth day of the Julian Period; thus, in the current year the dates would run January 2, 7, 12, &c. I should be very glad to see the co-ordinates of the planets given for the same dates referred to the same planes as those of the Sun. It does not seem necessary to give corrections of these to the apparent equinox of the day either for Sun or planets, but as regards the latter there would be an advantage in a correction to the equinox of a preceding and succeeding year, say the even tenth years preceding and succeeding. These co-ordinates could be computed as a step in passing from the Heliocentric longitudes and latitudes to the Geocentric right ascensions and declinations.

In the *Nautical Almanac* the places of the stars are referred to the beginning of the fictitious year, but the mean equinox for

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other purposes is that of January 1·0. There seems no reason for this variation, and I have proposed that, as in the *Connaissance des Temps* and the *Berliner Jahrbuch*, the beginning of the year should have only one meaning—that is, the moment when the Sun's mean longitude is 280°.

If the values of the day numbers in the *Nautical Almanac* be compared with those of the *Connaissance des Temps*, it will be found that towards the end of January and December there is a considerable difference between the C's and the D's. This is due to the fact that the terms of the expression for Nutation, depending on the longitude of the solar perigee, are omitted in the *Nautical Almanac*. There is also an additional quantity E omitted which is applicable to the right ascensions, and whose maximum value is $\pm 0''{\cdot}05$ or $\pm 0^{s}{\cdot}0033$. All these are very small quantities, but it does not seem right that they should be neglected when we consider the accuracy with which modern observations are reduced, as well as the fact that in the *Nautical Almanac* smaller periodic terms than some of these are retained. The quantities g, G, and f of the Independent Constants also require correction for the effects of the same terms. It appears unnecessary to continue Airy's day numbers, which are not required for use with the recent Greenwich Catalogue, and have never been required for the catalogues of other observatories. In fact, Mr. Stone's tables for finding a, b, c, &c., supersede all special calculations for the star numbers if his constants be accepted, and render Bessel's day numbers alone necessary when an ephemeris or several places of a star are required. Where it is a question of reducing single or very few observations of stars, the independent constants are best. The means of applying the terms of Nutation, which depend on the Moon's longitude, and change rapidly, should be given. This can be done in two ways. Their effects on C, D, f, g, and G, can be given separately, or they can be included at once in the daily values. The former plan is theoretically preferable, and I think the effects should be tabulated with the Moon's longitude as argument, for the change of arguments in a day is too great for convenient interpolation of the numbers, and this difficulty is only concealed, and not removed, by the latter practice, which, however, has the authority of the *Berliner Jahrbuch*. When any of the day numbers change sign, passing through 0, the logarithms become so irregular that their interpolation is impossible. In these cases it is desirable to give the natural numbers instead of the logarithms, with some suitable warning. In the *Berliner Jahrbuch* the natural numbers are given in addition to the logs., but this is hardly necessary. In the independent constants, also, log. i should be replaced by i under similar circumstances.

In what has preceded, I have spoken of the Nautical Section as a part of the General Almanac, but I do not think that the wants of navigation and geography will be met as fully as they should be by this arrangement. I have long felt that a smaller

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volume, which should omit all that was not useful to the wanderer, would be a boon; and the existence of various ephemerides, containing selections from the *Nautical Almanac*, with tide tables, and various information as to special ports, shows that the want has been felt in England, though no official attempt has been made to meet it. Elsewhere the case is different. In America, under the title of the *American Nautical Almanac*, a small volume* has been annually published for the use of navigators, and this, again, has been further simplified in two smaller volumes, for the especial use of coasters on the East and West coasts respectively. The German Government have published at Berlin, under the editorship of Dr. Tietjen, a very handy volume called the *Nautisches Jahrbuch*; and more recently the Austrian Government have published at Trieste a volume called the *Astronomische Nautische Ephemeriden*, edited by Dr. Anton, of which the text would seem to be given in more than one of the languages of that Empire. France, too, has begun a series of extracts from the *Connaissance des Temps*, for the use of the Marine. Of these I think the Berlin volume would be far the best type to follow. The arrangement, indeed, is not that which I prefer, but it would be intelligible to those using it. With slight exceptions, it contains all that a surveyor or traveller by land or sea can want. One shortcoming is in the Elements of Occultations, where, though the data suffice for calculating a longitude from an observed occultation, they do not at once do so for predicting the circumstances for a given place, the power of doing which is essential to any systematic use of occultations. In this respect Dr. Anton's volume is more satisfactory. Both should, I think, give the elements and charts for eclipses. I do not think the data for *Jupiter's* satellites are of much use. They may occasionally furnish an approximate longitude when the stay at a station is very short; but for anything like satisfactory observation they require more optical means than the traveller generally has—means requiring carriage facilities which I think would justify our expecting him to adopt a better mode of determining longitude than lunar distances.

Some sixty years ago, a Committee of our Society, under authority from the Admiralty, devised the arrangement of the *Nautical Almanac* substantially as it now exists; small changes have been made, all in the direction of advance, but the lapse of time seems to me to make it desirable that there should be a new committee representative of the interests concerned. And I do not think that the plan of starting the changes determined on, and leaving the matter to official supervision, is quite satisfactory. I should like to see a more permanent consultative

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* This is in fact extracted from the General American Ephemeris, which will be found of late years to be divided into sections somewhat as I have proposed. Professor Newcomb has been good enough to send copies of these Nautical Publications through me to the Library.

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body, whose duty it should be to receive, consider, and decide on questions of proposed changes. The *Nautical Almanac* comes in contact with such large classes of men scattered over the world, that it is hardly possible that the experience of one or two officials in London can meet all the wants of those using it. It is no reflection, then, on those who have had the guidance of our ephemeris that they have not succeeded perfectly in an impossible task; indeed, that after some sixty years of uncontrolled management, the *Nautical Almanac* is so little behind the times is the best testimony to the care which has been given to it. But we should not be content with this. A Nation whose ships are in every Sea, and whose Colonies surround the globe, should not be content to lag behind, but should be amongst the leaders in giving facilities for its widely-scattered astronomers, mariners, and geographers.

P.S.—The Astronomer Royal has stated that Hansen's Tables include empirical terms, and I believe that some of his coefficients have been determined so as to make the Tables agree with observation; theory, however, prescribed the arguments and the numbers are Hansen's. Two of Newcomb's corrections are purely empirical and have no foundation in theory, and the other three, which I have proposed to print in the Ephemeris, arise from changes made in Hansen's data; they may be improvements, but they cannot be considered part of Hansen's Tables.

Note on the Apparent Star Places of the Nautical Almanac.

By H. H. Turner, M.A., B.Sc.

In the course of the longitude operations recently undertaken at the Royal Observatory, Greenwich, occasion arose for comparing the places of the circumpolar stars given in the *Nautical Almanac* with those of other almanacs, viz. the *Connaissance des Temps*, the *Berliner Jahrbuch*, and the *American Ephemeris*, which will hereafter be designated *C.T.*, *B.J.*, and *A.E.* respectively. The meridians being different, simple interpolation must be used for such comparisons, except in the case of the *N.A.* and *C.T.*, where the difference of meridians is so small as to render this unnecessary.

The apparent places may be regarded as the sum of two terms: (1) the adopted mean place, and (2) the star correction. The first depends on previous observations generally selected from national sources, and is therefore different in different almanacs; but the second is a mere matter of computation, the elements for which are known with such accuracy that the results might be expected to agree very closely.

The original comparison referred to the years 1889 and 1890, and it was found that for these years the star corrections for